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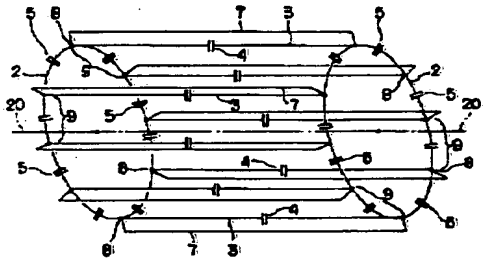
(54) MULTIPLEX TUNING TYPE HIGH FREQUENCY COIL FOR MAGNETIC RESONANCE IMAGING EQUIPMENT

(57) Abstract:

PROBLEM TO BE SOLVED: To provide a multiplex tuning type high frequency coil for magnetic resonance imaging(MRI) equipment by which the axial length of a uniform sensitivity area is not changed by a frequency without lowering transmission/ reception sensitivity.

SOLUTION: In this multiplex tuning type high frequency coil for MRI equipment, plural 1st wire conductors 3 are cylindrically arranged, plural 2nd wire conductors 7 are cylindrically arranged outside these 1st wire conductors 3 as well, the 1st and 2nd wire conductors 3 and 7 are electrically connected to two opposed ring conductors 2 while sharing nodes 8, capacitance elements 5 are inserted one by one between the adjacent nodes 8 to the respective two ring conductors 2, and capacitance elements 4 are inserted to the 1st wire conductors 3 one by one.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the multiplex alignment mold high frequency coil for magnetic-resonance-imaging equipments which can be aligned with two or more frequencies.
[0002]
[Description of the Prior Art] Magnetic-resonance-imaging equipment is equipment which converts the chemical and physical microscopic information on the matter into a video signal, or observes a chemical shift spectrum using the phenomenon which absorbs in resonance the energy of the RF magnetic field rotated on a specific frequency, when the ensemble of a nucleus with the magnetic moment of a proper is placed all over a uniform static magnetic field as known well.
[0003] In order to excite the specific atomic nucleus in the area of interest of analyte with such magnetic-resonance-imaging equipment or to detect MR signal from a specific atomic nucleus, a high frequency coil is indispensable.
[0004] By the way, the signal of the compound containing 31P (Lynn), 19F (fluorine), 13C (carbon), 23N (sodium), etc. is detected, and MRS (magnetic resonance spectroscopy) and MRSI (magnetic resonance SUPEKUTOROSUKO pick imaging) which observe a metabolic turnover condition in the living body are capturing the spotlight in recent years.
[0005] however, the concentration of these elements in the living body is very thin -- since the relative sensibility to 1H (proton) is very low -- technique, such as a polarization transfer, -- using -- A cure, such as performing signal observation by 1H, is taken.
[0006] In such a case, in a high frequency coil, it is 31P grade. The double concordance which aligns with both 1H is required. Furthermore, when observing the integrated state of two or more nuclear species, three-fold or more concordance is required.
[0007] The birdcage mold duplex alignment high frequency coil of the shape of a cylinder with equalization of transceiver sensibility which shows structural drawing to drawing 11 and shows an example to drawing 12 for an equal circuit good as such a double alignment high frequency coil is known.
[0008] However, in such a conventional double alignment high frequency coil, since the path of the high frequency current of flowing in a coil changed with frequencies, there was a problem that transceiver sensibility will differ depending on a frequency. This problem was mentioned above. It is inconvenient especially when observing the integrated state of the signal observing method or two or more nuclear species by 1H.
[0009] if the double alignment high frequency coil of drawing 11 is specifically explained to an example -- a low frequency current -- the two shape of an inside ring -- a conductor 101 and a line parallel to a shaft -- although it mainly flows to a conductor 102 -- a high-frequency current -- the two shape of an outside ring -- a conductor 103 and a line parallel to a shaft -- it mainly flows to a conductor 102.
[0010] Therefore, if the field where transceiver sensibility is uniform is compared, the direction of a RF will become larger than low frequency. for making these fields into the same size -- the shape of an internal and external ring -- although a conductor 101,103 must be made to approach, especially if it carries out like this, RF sensibility will deteriorate. in order to prevent this sensibility degradation -- the shape of an inside ring -- the distance of a conductor 101 -- the shape of an outside ring -- about [of spacing of a conductor 103] -- being referred to as one half is common.
[0011] Therefore, the sensibility homogeneity field of low frequency will become straitness called abbreviation one half to shaft orientations to a RF. For this reason, if human head section photography is assumed, since the axial length of this high frequency coil is restricted by interference of both shoulders, the problem that it is not stored in the sensibility homogeneity field of low frequency will produce the whole head.
[0012] As structure is shown in drawing 13 in order to cancel frequency dependent [of such a sensibility area size] and to make the sensibility homogeneity field of both frequencies the same for example, it considers approaching the both ends of a capacitance component in an inductance, but since the great portion of energy of a coil is accumulated in the parallel resonant circuit which consists of an above-mentioned inductance and a capacitance component in that case, the fall of RF sensibility will be caused.
[0013]
[Problem(s) to be Solved by the Invention] The purpose of this invention aims at offering a multiplex alignment mold high frequency coil for magnetic-resonance-imaging equipments from which the die length about the

shaft orientations of the field where sensibility is uniform moreover does not change with frequencies, without dropping transceiver sensibility.
[0014]
[Means for Solving the Problem] The multiplex alignment mold high frequency coil for magnetic-resonance-imaging equipments by this invention the two shape of a ring countered and arranged -- this shape of a conductor and a ring -- the plurality arranged by tubed that it should connect with a conductor -- with a conductor the 1st line It has a conductor the 2nd line. this plurality arranged by tubed the 1st line on the outside of a conductor -- said 1st line -- a conductor and the two shape of said ring which counters a conductor the 2nd line -- a node is shared to a conductor -- making -- electric -- connecting -- the two shape of said ring -- at least to one side of a conductor during an adjacent node -- the 1st capacitance component -- inserting -- said 1st line -- a conductor -- or -- said -- it comes to insert the 2nd capacitance component in a conductor the 2nd line (Operation) constituting in this way -- the 1st line -- a conductor and this 2nd line that shares a conductor and a node the 1st line -- a conductor and the 1st line -- a conductor or the 2nd capacitance component inserted in the conductor the 2nd line to a parallel resonant circuit -- the shape of moreover, a ring inserted into the adjacent node -- the shape of some conductors and a ring -- a series resonant circuit consists of 1st capacitance components inserted in the conductor, respectively.
[0015] the 1st line of the inside in which, as for the current, the 2nd capacitance component is inserted the 2nd line with the conductor the 1st line the one where an impedance with a conductor is lower that is, in high frequency -- a conductor -- mainly -- flowing -- an impedance -- relative -- a high outside -- since it hardly flows to a conductor the 2nd line, a parallel resonant circuit shows capacitive. On the other hand, a series resonant circuit shows inductivity equivalent. Therefore, in high frequency, it can be regarded as the birdcage mold coil of a low-pass mold.
[0016] on the other hand -- low frequency -- a current -- an impedance -- relative -- the 1st line of the high inside -- a conductor -- almost -- not flowing -- an impedance -- relative -- a low outside -- since it mainly flows to a conductor the 2nd line, a parallel resonant circuit shows inductivity. On the other hand, a series resonant circuit shows capacitive equivalent. Therefore, in low frequency, it can be regarded as the birdcage mold coil of a highpass mold.
[0017] thus, double alignment -- realizable -- moreover -- a current -- a RF and low frequency -- not depending -- the shape of same ring -- since a conductor is flowed, the sensibility homogeneity field of a RF and the sensibility homogeneity field of low frequency become the same die length about shaft orientations.
[0018]
[Embodiment of the Invention] Hereafter, with reference to a drawing, the multiplex alignment mold high frequency coil for magnetic-resonance-imaging equipments concerning this invention is explained. This high frequency coil is explained as double alignment on [of explanation] expedient, although it is the so-called multiplex alignment mold which can be aligned with two or more frequencies.
(The 1st operation gestalt) The structure of the high frequency coil of the 1st operation gestalt is shown in drawing 1 . This high frequency coil is the thing of the type with which the conductor is called the so-called "birdcage" constructed in the shape of a cylindrical shape. The reference mark 20 is illustrating the medial axis of this cylinder. two or more lines which have fixed die length around this medial axis 20 -- the conductor (a conductor is called the 1st line hereafter) 3 is arranged in the shape of a cylinder. that is, plurality -- parallel moreover, the conductor 3 is discretely arranged tidily at fixed spacing in the equidistant location from the medial axis 20 with the medial axis 20 the 1st line.
[0019] the same -- this 1st line -- the outside of a conductor 3 -- the 1st line -- the line of the number same by the same die length as a conductor 3 -- the conductor (a conductor is called the 2nd line hereafter) 7 is arranged in the shape of a cylinder. that is, plurality -- parallel moreover, the conductor 7 is discretely arranged tidily at fixed spacing in the equidistant location from the medial axis 20 with the medial axis 20 the 2nd line.
[0020] the two inside shape of and a ring which the conductor 3 was made to counter the 1st line -- in a node 8, it has connected with a conductor 2 electrically. the same -- the 2nd outside line -- a conductor 7 -- the 1st line -- a conductor 3 and a node 8 -- sharing -- the shape of two ring -- it has connected with a conductor 2 electrically.
[0021] these shape of two ring -- a conductor 2 is alike, respectively and it is inserting the capacitance component 5 at a time between [one] the adjacent nodes 8. Every one capacitance component 4 is inserted also near the center of a conductor 3 (or the 2nd line conductor 7) the 1st line.
[0022] A part of structures of drawing 1 are shown in the detail at drawing 2 . the 1st -- the cylindrical array of

conductors 3 and 7 is held the 1st and by forming conductors 3 and 7 the 2nd line, respectively the 2nd line on the inside 1 and the outsides 6 of the duplex cylinder structure made of resin, such as a nonmagnetic plastic or an acrylic, ABS, and Teflon.

[0023] Thus, the constituted double alignment high frequency coil is expressed in the equal circuit of drawing 3 . As for this high frequency coil, it comes to put two or more parallel resonant circuits 30 and two or more series resonant circuits 40 together on a circuit. The parallel resonant circuit 30 is constructed the 1st line with a conductor 3 and this capacitance component 4 that shares a conductor 3 and a node 8 the 1st line and that is inserted in the conductor 3 the 1st line with the conductor 7 the 2nd line. the shape of a ring inserted into the node 8 when a series resonant circuit 40 adjoins each other on the other hand -- the shape of some conductors (this part is hereafter called a ring element) 2 9 and a ring -- it is constructed with the capacitance component 5 inserted in the conductor 2.

[0024] By such configuration, two resonance frequencies which can align are [omegaH and] omegaL about the lower one in the higher one. If it carries out, it will be given as follows. L1 [in addition,] -- the inductance of the ring element 9 of a series resonant circuit 40, and C3 -- the capacity of the capacitance component 5 of a series resonant circuit 40, and L2 -- a parallel resonant circuit 30 -- the inductance of a conductor 7 and C4 are the capacity of the capacitance component 4 of a parallel resonant circuit 30 the 2nd line. Moreover, N is the number of the elements which consist of one parallel resonant circuit 30 and one series resonant circuit 40.

[0025]

[Equation 1]

$$\omega_h=\sqrt{(c+\sqrt{d})}$$

$$\omega_l=\sqrt{(c-\sqrt{d})}$$

$$c=(\omega_3^2+\omega_4^2)/2+1/(2L_1C_4)\cdot\sin^2(\pi/N)$$

$$d=((\omega_3^2-\omega_4^2)/2)^2 + (\omega_3^2+\omega_4^2)/(2L_1C_4)\cdot\sin^2(\pi/N) + 1/(4L_1^2C_4^2)\cdot\sin^4(\pi/N))$$

$$\omega_3^2=1/(L_1C_3),\quad \omega_4^2=1/(L_2C_4)$$

N：エレメント数

[0026] the 1st line of the inside in which, as for the current, the capacitance component 4 is inserted the 2nd line with the conductor 3 the 1st line the one where an impedance with a conductor 7 is lower that is, in high frequency -- a conductor 3 -- mainly -- flowing -- an impedance -- relative -- a high outside -- since it hardly flows to a conductor 7 the 2nd line, a parallel resonant circuit 30 shows capacitive. On the other hand, a series resonant circuit 40 shows inductivity equivalent. Therefore, in high frequency, it can be regarded as the birdcage mold coil of a low-pass mold.

[0027] on the other hand -- low frequency -- a current -- an impedance -- relative -- the 1st line of the high inside -- a conductor 3 -- almost -- not flowing -- an impedance -- relative -- a low outside -- since it mainly flows to a conductor 7 the 2nd line, a parallel resonant circuit 30 shows inductivity. On the other hand, a series resonant circuit 40 shows capacitive equivalent. Therefore, in low frequency, it can be regarded as the birdcage mold coil of a highpass mold.

[0028] thus -- this example -- double alignment -- realizable -- moreover -- a current -- a RF and low frequency -- not depending -- the shape of same ring -- since a conductor is flowed, the sensibility homogeneity field of a RF and the sensibility homogeneity field of low frequency can be formed in the same die length about shaft orientations.

[0029] in addition -- above-mentioned explanation -- the inside -- although the capacitance component 4 was inserted in the conductor 3 the 1st line -- an outside -- you may make it insert the capacitance component 4 in a conductor 7 the 2nd line

(The 2nd operation gestalt) The structure of the high frequency coil of the 2nd operation gestalt is shown in drawing 4 . The same sign is given to the same part as drawing 1 , and explanation is omitted.

[0030] the 2nd operation gestalt is different from the 1st operation gestalt -- the 1st operation gestalt -- the

capacitance component 4 -- inside having inserted in the conductor 3 the 1st line -- receiving -- a **** 2 operation gestalt -- the capacitance component 4 -- the inside -- the 1st line is in the point of a conductor 3 and an outside inserted in the conductor 7 by turns the 2nd line.
[0031] As mentioned above, the current path of shaft orientations is different by the RF and low frequency with the 1st operation gestalt. that is, a high-frequency current -- the 1st inside line -- a conductor 3 -- flowing -- reverse -- a low frequency current -- an outside -- a conductor 7 is flowed the 2nd line. Therefore, depending on the differences of the some of the radius distance of both paths, the transceiver sensibility to a medial axis 20 can say that it is very small, and is different.
[0032] a high-frequency current -- the 1st inside line -- a conductor 3 and the outside which inserted the capacitance component 4 with a conductor 7 the 2nd line -- flowing -- on the other hand -- a low frequency current -- the inside -- it flows the 1st line in a conductor 3 and the outside which is not inserting the capacitance component 4 with a conductor 7 the 2nd line.
[0033] it mentioned above -- as -- this operation gestalt -- like -- the capacitance component 4 -- the inside path which can turn at both the high frequency current and a low frequency current the 1st line by [of a conductor 3 and an outside] having inserted in the conductor 7 by turns the 2nd line -- the 1st inside line -- a conductor 3 and an outside -- it does not incline toward one side with a conductor 7 the 2nd line.
[0034] therefore, the difference between the transceiver sensibility to the medial axis 20 in a RF, and the transceiver sensibility to the medial axis 20 in low frequency -- zero -- or-izing can be carried out [minimum], so that it can ignore.
(The 3rd operation gestalt) The structure of the high frequency coil of the 3rd operation gestalt is shown in drawing 5 . the 3rd operation gestalt is different from the 1st operation gestalt -- the shape of two ring -- the shape of either of the conductors 2, and a ring by the side of insertion opening (A) which specifically inserts analyte into a cylinder, and reverse -- a conductor 2 -- disc-like -- it is in the point replaced with a conductor 11.

[0035] disc-like [this] -- the so-called mirror image phenomenon demonstrates with a conductor 11 -- having -- as -- disc-like -- the field where transceiver sensibility is uniform is substantially expanded as if the high frequency coil of the same configuration also as the opposite side of a conductor 11 existed.
[0036] in addition, the annular conductor with which opening of the central part was carried out like drawing 6 although it assumed that this inserted analyte from a direction (A) -- 11' is adopted and you may enable it to insert analyte even from a reverse direction (B)
[0037] in addition -- above-mentioned explanation -- the inside -- although the capacitance component 4 was inserted in the conductor 3 the 1st line -- an outside -- you may make it insert the capacitance component 4 in a conductor 7 the 2nd line
(The 4th operation gestalt) Although double alignment explained the 1st operation gestalt, it is extensible to three-fold or more multiplex alignment in fact. The **** 4 operation gestalt is concerned with this extended approach.
[0038] The structure of the high frequency coil of the 4th operation gestalt is shown in drawing 7 . A part of structures of drawing 7 are shown in the detail at drawing 8 . the 4th operation gestalt is different from the 1st operation gestalt -- the 1st inside line -- a conductor 3 -- respectively -- alike -- every two -- the capacitance components 13 and 14 -- inserting -- between these capacitance components 13 and 14 -- the 1st inside line -- the 2nd line of a conductor 3 and an outside -- a conductor 7 -- communication -- it is in the point connected with the conductor 12.
[0039] The equal circuit of the high frequency coil by this operation gestalt is shown in drawing 9 . By having constituted, as mentioned above, two parallel resonant circuits 50 and 60 will be connected to a serial. Although inductive coupling between resonance circuits exists, if this is disregarded, it is simplified and it thinks in order to make a principle intelligible, an electrical equivalent circuit (drawing 9), drawing 7 , and the relation of 8 will be considered as follows.
[0040] namely, the parallel resonant circuit 50 -- almost -- communication -- it is thought that it is constructed with the capacitance component 13 of the outside of the inside separated with the conductor 12 the 1st line has some conductors 3 17, this part 17, and a juxtaposition relation inserted in some conductors 3 17 the 1st line with some conductors 7 15 the 2nd line.
[0041] on the other hand -- a parallel resonant circuit 60 -- almost -- communication -- it is thought that it is constructed with the capacitance component 14 of the outside of the inside separated with the conductor 12 the 1st line has some conductors 3 18, this part 18, and a juxtaposition relation inserted in some conductors 3 18 the

1st line with some conductors 7 16 the 2nd line.
[0042] The frequency characteristics of the impedance of two parallel resonant circuits 50 and 60 by which series connection was carried out to drawing 10 (a) in this drawing (b) in the frequency characteristics of the impedance of the series resonant circuit 40 of the ring element 9 are shown. In addition, the resonance frequency of omega1P and a parallel resonant circuit 60 is expressed [the resonance frequency of a series resonant circuit 40] for the resonance frequency of omega 11 and a parallel resonant circuit 50 as omega2P.
[0043] drawing 10 -- a dotted line -- having been shown -- a frequency -- omega -- one -- ' -- omega -- two -- ' -- omega -- three -- ' -- a series resonant circuit -- 40 -- a parallel resonant circuit -- 50 -- a parallel resonant circuit -- 60 -- series resonance -- a condition -- becoming -- a coil -- the whole -- the resonance state -- relating -- having . Three resonance frequencies omega 1 which can actually align, omega 2, and omega 3 When the total of the basic element which a series resonant circuit 40, a parallel resonant circuit 50, and a parallel resonant circuit 60 become at a time from one is made into N individual, it is given as follows.
[0044]
[Equation 2]

$$\omega_1=\omega_1' \cdot (1/\sin(\pi/N))$$
$$= (1/\sqrt{L_1' C_1'}) \cdot (1/\sin(\pi/N))$$

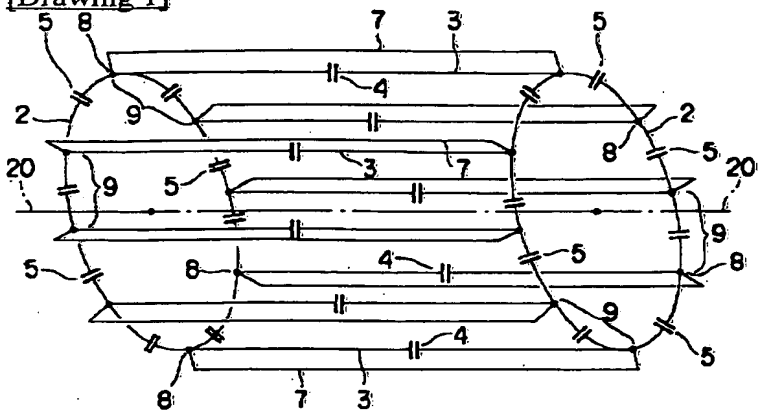
$$\omega_2=\omega_2' \cdot \sin(\pi/N)$$
$$= (1/\sqrt{L_2' C_2'}) \cdot \sin(\pi/N)$$

$$\omega_3=\omega_3' \cdot \sin(\pi/N)$$
$$= (1/\sqrt{L_3' C_3'}) \cdot \sin(\pi/N)$$

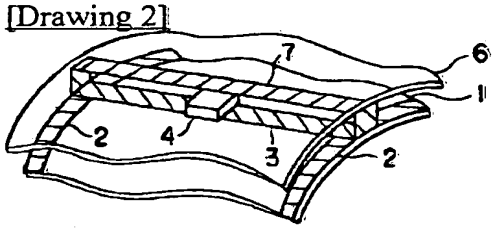
[0045] What is necessary is just to increase the number of circuits of the parallel resonant circuit by which series connection is carried out, in order to increase tuning frequency furthermore. Without being limited to the operation gestalt mentioned above, this invention can deform variously and can be carried out. For example, although above-mentioned explanation explained as what was constructed in the shape of a cylindrical shape, you may also construct in the shape of an ellipse cartridge.
[0046]
[Effect of the Invention] According to this invention, moreover, the sensibility homogeneity field of a RF and the sensibility homogeneity field of low frequency can be formed in the same die length about shaft orientations, without dropping send efficiency and signal detection sensitivity.

DRAWINGS

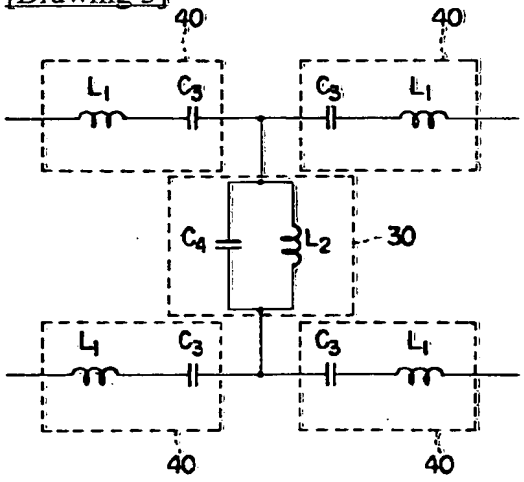
[Drawing 1]



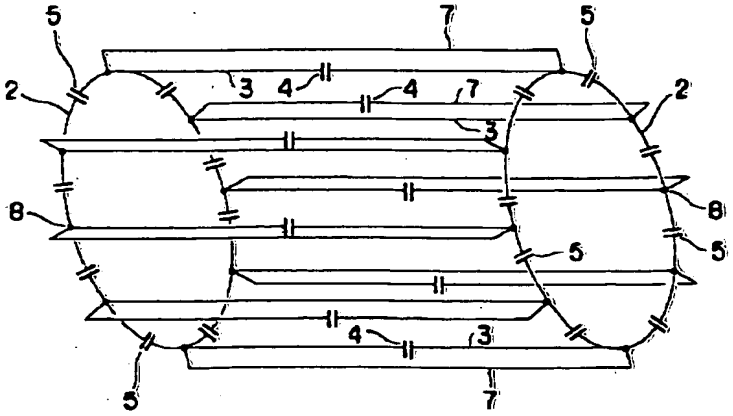
[Drawing 2]



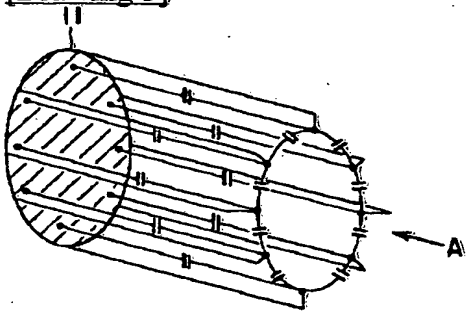
[Drawing 3]



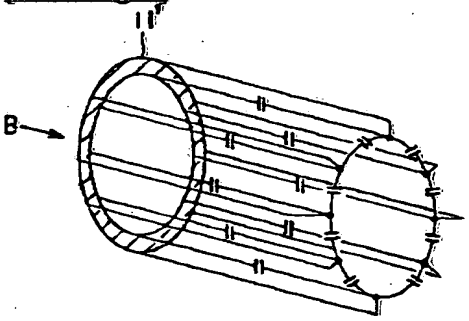
[Drawing 4]



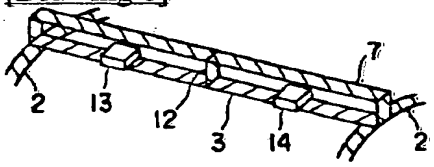
[Drawing 5]



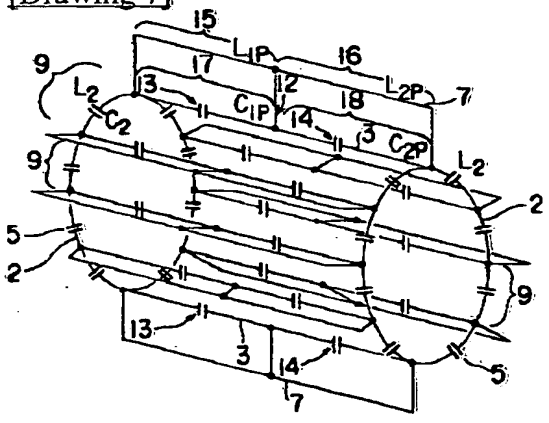
[Drawing 6]



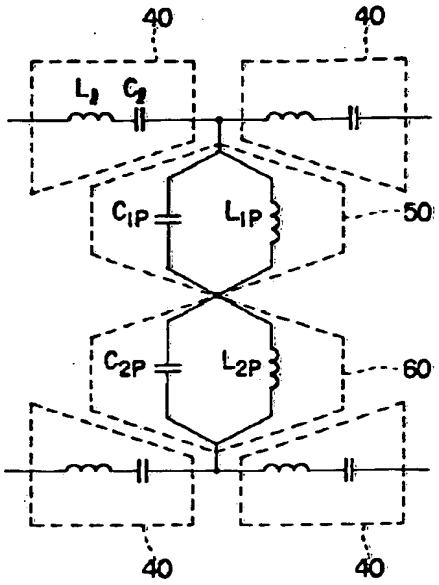
[Drawing 8]



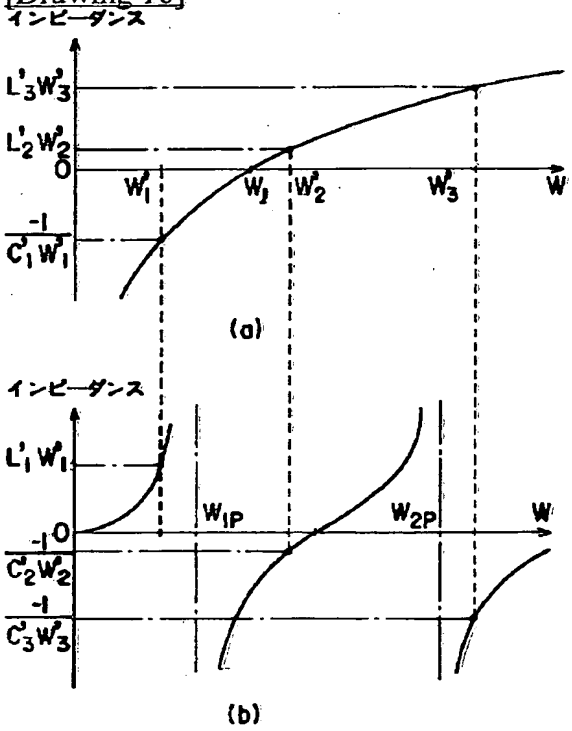
[Drawing 7]



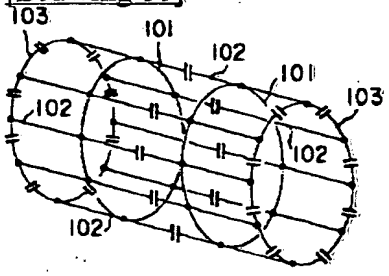
[Drawing 9]



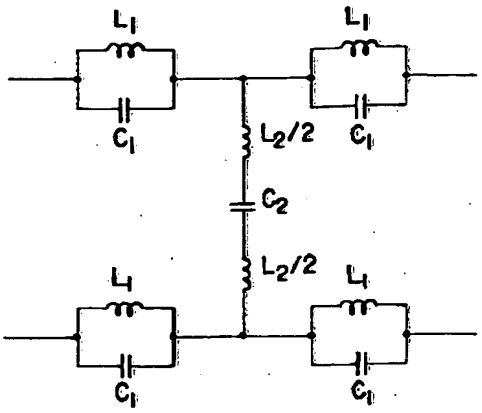
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Drawing 13]